



Commercial Crew Program Status to NASA Advisory Council

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Aug 27, 2018**







Agenda



- **Agenda**
 - **CCP Status**
 - Program Progress
 - Timeline to the International Space Station
 - Crew Assignments
 - **Boeing OFT/CFT Mission Status**
 - **SpaceX Demo-1/Demo-2 Status**
 - **Space Act Agreement Status**
 - Blue Origin Status
 - Sierra Nevada Corporation Status
 - Enabling Commercial Space
 - **Summary**



Program Progress

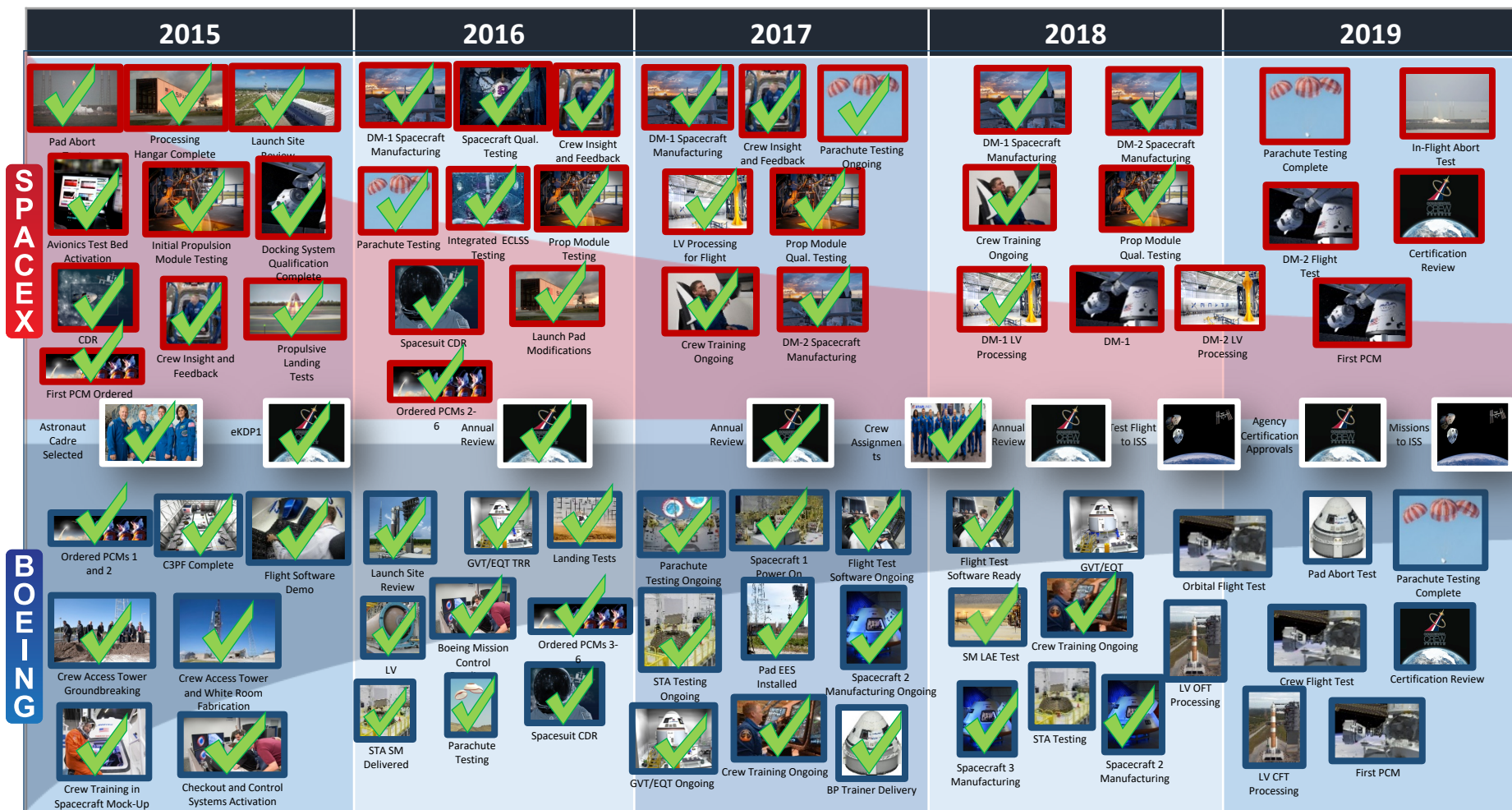


CCP has made significant progress over the last quarter, notably:

- **Mission planning and preparations for eight CCP missions are in work:**
 - Official Dates For Boeing:
 - Late 2018/ Early 2019: Orbital Flight Test (unmanned demo)
 - Mid 2019: Crewed Flight Test (demo)
 - PCM-1 awarded May 2015
 - PCM-2 awarded in December 2015
 - PCM-3,4,5,6 awarded in January 2017
 - Official Dates For SpaceX:
 - November 2018: Flight to ISS without crew (Demo Mission 1)
 - April 2019: Flight to ISS with crew (Demo Mission 2)
 - PCM-1 awarded November 2015
 - PCM-2 awarded July 2016
 - PCM-3,4,5,6 awarded in January 2017
- **Space hardware manufacturing, testing and qualification are underway**
- **Both providers are making tangible progress toward flight tests and crewed missions to the International Space Station**
- **Continued CCP team engagement as the providers perform critical test and verification events**
- **Continue to make progress in the burn down of key certification products with the providers**
 - Progress for each provider is included in provider-specific sections of this briefing



Timeline to the International Space Station



Last Updated
Aug 2018



Crew Assignments



- **Nine U.S. astronauts have been assigned to fly the initial test flights and post certification missions to the International Space Station aboard America's first commercially built spacecraft**



Boeing Crew Flight Test

Eric Boe
Nicole Mann
Chris Ferguson(Boeing)



SpaceX Demo-2

Bob Behnken
Doug Hurley



Boeing First Mission

Josh Cassada
Suni Williams



SpaceX First Mission

Victor Glover
Mike Hopkins



Boeing OFT/CFT Mission Status





Boeing Accomplishments



• Design, Development, Test, and Evaluation

• System Level

- Structural Test Article (STA) testing progressing at Huntington Beach 12 of 15 tests completed
 - Completed CM/SM Base Heat Shield jettison test series
- Remaining test campaigns:
 - Ascent Cover Separation series planned start in late fall
 - Forward Heat Shield / Parachute Impact testing planned start in fall
 - CM Fixed Tunnel test series planned start late summer, test concludes STA campaign
 - Major vehicle reconfiguration underway and required to support Fixed Tunnel test start

• Subsystem Level

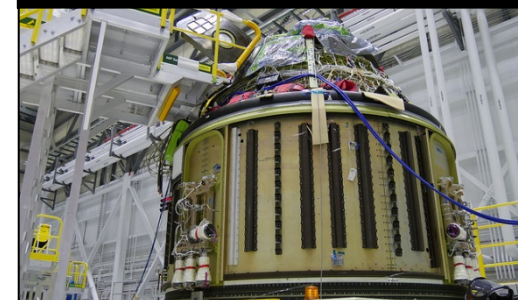
- Land Landing Qualification Testing completed (all 14 tests), Report completed
- Parachute System Qualification Testing underway (3 of 5 completed)
 - Remaining 2 tests planned thru summer
- Launch Abort Engine Hot Fire ATP completed
- Service Module Hot Fire testing nearing completion at White Sands Test Facility
 - Test series 1 Cold Flow complete and series 2 Propellant Servicing complete
 - Test series 3 Low Altitude Hot-Fire testing complete
 - Remaining Tests: High altitude aborts and nominal mission sequence

• Joint Tests (JT) and analysis with ISS

- Joint testing and analysis required for ISS integration is progressing
- Completed Joint Tests:
 - JT1 SW input output, JT6 Remote Terminal validation,
 - JT7 power qualification and electromagnetic compatibility,
 - JT 9A RF compatibility, JT 2 command & telemetry routing
 - JT 8 CST-100 to NDS interface test complete (EQT/CFT SC#3)
- Remaining Joint Tests:
 - JT 4 Integrated Software Stage Test
 - JT 8 CST-100 to NDS interface acceptance test (OFT SC#3)
 - JT9B C2V2 RF Interface test: Data & Audio verification test
 - JT 9C C2V2 RF Interface test: CST-100 Encryption verification test
 - JT 10 Crew Equipment Interface Test (CEIT)
 - JT 11 Microbial and Fungal Sampling
 - JT 13 ISS/CST-100 Flight Article Validation Test



CM/SM Stack for Sep Test



SC #1 PAT Test Article



**SMHF Cold Flow Prop Tank
Skid & Flow Control Valves**

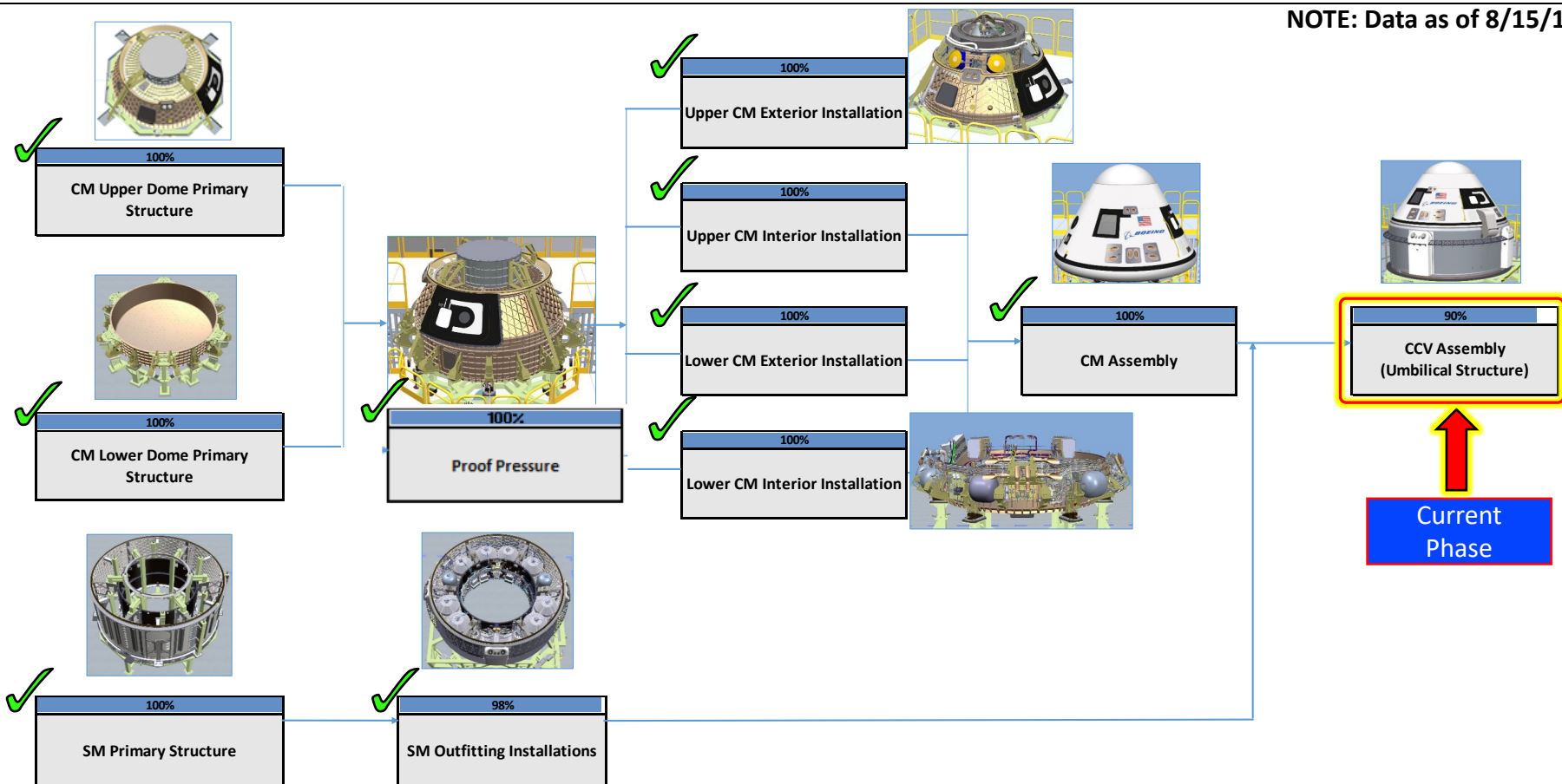


Boeing Spacecraft Production Status



• Spacecraft #1 (SC#1): Pad Abort Test (PAT) vehicle production build progress

NOTE: Data as of 8/15/18



• SC#1 Status: CM & SM stand alone builds complete. Currently in CM Integrated Assembly phase

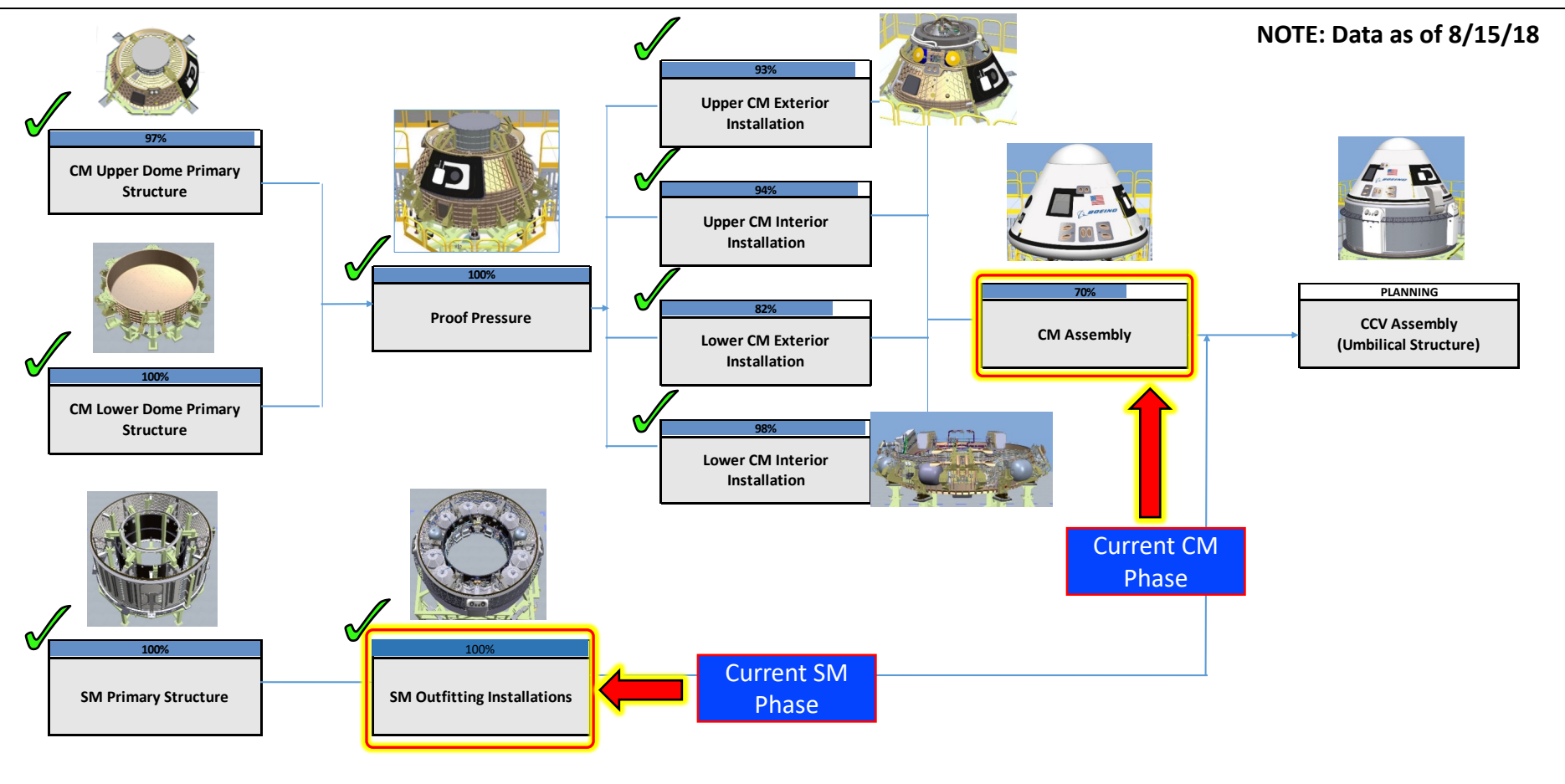
- Completed CCV acceptance testing
- Completing preps for shipment
- PAT Test Article target ship to WSMR TBD to support Pad Abort Test



Boeing Spacecraft Production Status



- **Spacecraft #2 (SC#2): Environmental Qualification Test (EQT) vehicle and Crewed Flight Test (CFT) production build progress**



- **SC#2 Status: Currently, in the CM Assembly Phase and the SM Integrated Assembly**
 - First Light testing completed early summer, progressing towards CM/SM mate
 - EQT Test Article shipped to El Segundo August 13 to support EQT start
 - EQT Crew Module target ship to El Segundo late summer

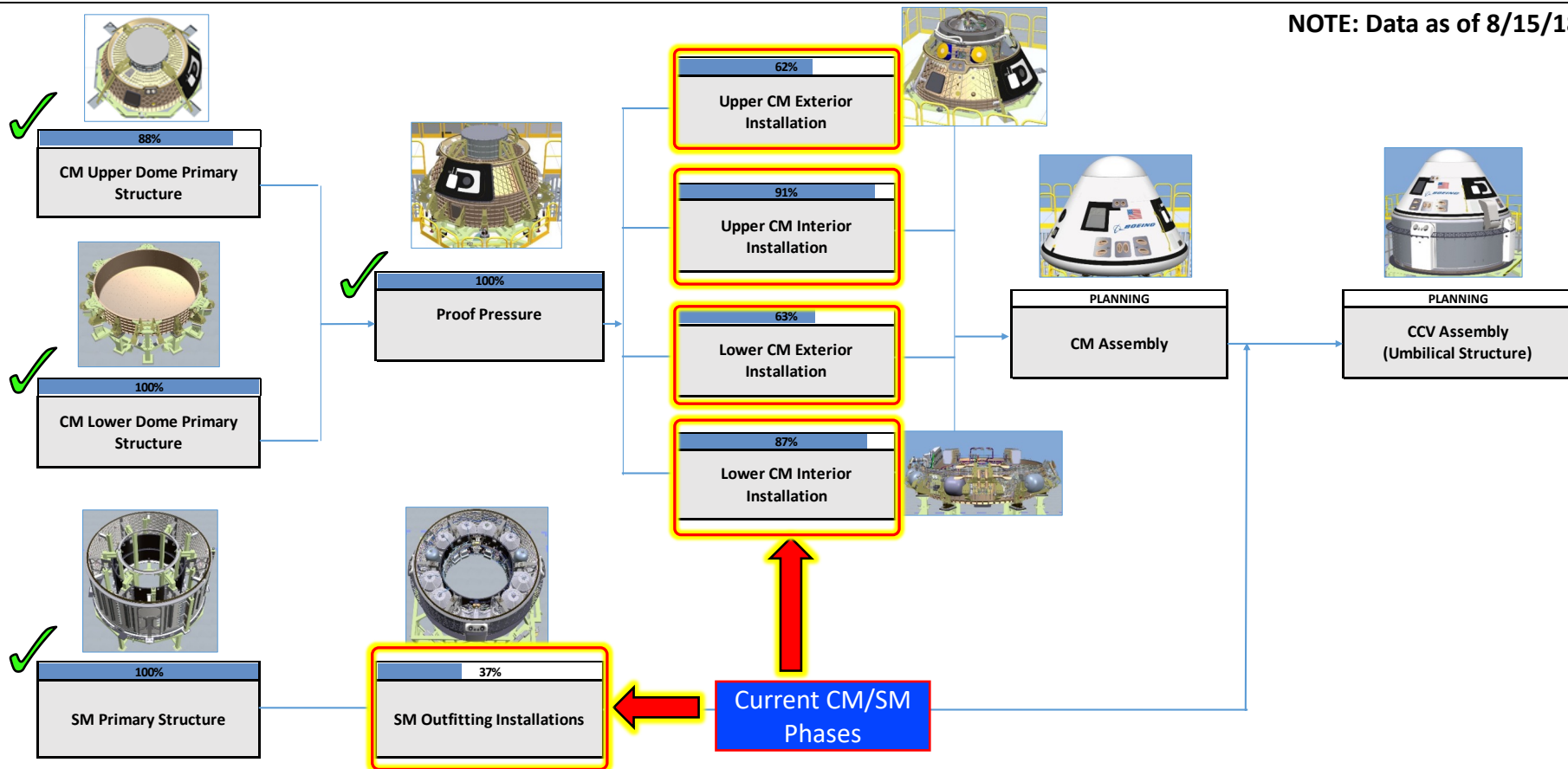


Boeing Spacecraft Production Status



• Spacecraft #3 (SC#3): Orbital Flight Test (OFT) production build progress

NOTE: Data as of 8/15/18



- **SC#3 Status: Currently, in the Upper Dome Assembly Phase, the Lower Dome Assembly Phase, and the SM Integrated Assembly**
 - Lower Dome 1st light completed (initial vehicle power)
 - Progressing towards CM/SM mate fall



Boeing Launch Vehicle Production Status



- **Launch Vehicle Build Progress**

- **Atlas V (AV-080) OFT Launch Vehicle**

- **Booster, Centaur, and Launch Vehicle Adapter nearing final build completion with target ship to CCAFS late summer**
 - **Booster**
 - Production Complete
 - Target ship to CCAFS fall
 - **Centaur**
 - Final harness installs in work
 - Production complete target mid summer
 - Ship to CCAFS target late fall

- **Atlas V (AV-082) CFT Launch Vehicle**

- **Booster**
 - RP/LOX tank splice planned for mid summer
 - Avionics box installations remain in work
 - Production complete target late fall
 - **Centaur**
 - RL-10 engine build up and verification testing complete
 - Install planned for mid summer
 - Production complete target late fall



Atlas V Booster AV-080 (OFT)



Atlas V DEC AV-080 (OFT)



Atlas V Booster AV-082 (CFT)



Boeing Operations Status



- **Flight Operations Reviews**

- **ISS Joint Flight Operations Review**

- Completed June 25th – 29th
 - Focused on ISS Joint Ops Product definition:
 - LCCs, Flight Rules, Joint Operations Interface Procedures, Operations Data Files

- **Boeing Flight Operations Review**

- Completed July 9th – 12th
 - Focused on Boeing stand-alone Ops Product definition:
 - Ground and Pre-Launch Procedures, LCCs, Flight Rules, Flight Data Files

- **Simulations**

- **Joint Ascent Simulations with ULA and NASA**

- Completed OFT Integrated Crew Exercise (ICE) #1
 - Completed On-Pad Crew Emergency Egress Testing
 - OFT Systems Rehearsal planned for summer
 - OFT ICE #2 planned for fall
 - OFT Mission Dress Rehearsal (MDR) #1 planned for fall
 - OFT Wet Dress Rehearsal Planned (WDR) for fall
 - OFT Final MDR Planned for fall

- **Joint Simulations with ISS**

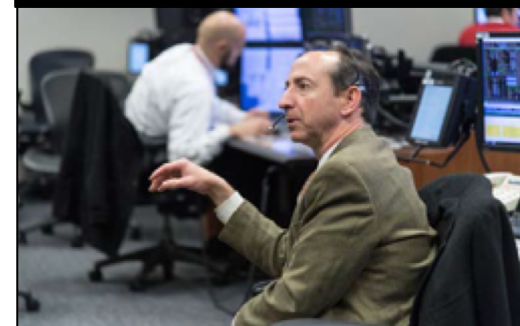
- Completed (2) generic Joint Rendezvous docking sims with ISS

- **Landing Simulations**

- Completed field equipment integration & training at WSMR site
 - Completed Landing Recovery Team Paper Sim #5
 - Landing Systems Rehearsal #1 planned for fall
 - Landing Systems Rehearsal #2 planned for fall



OFT ICE #1 Sim



Joint Rendezvous Mission Ops Sequence Test



Landing Site Field Training



SpaceX Demo-1/Demo-2 Mission Status





SpaceX Accomplishments



- **Development progress**

- **Dragon**

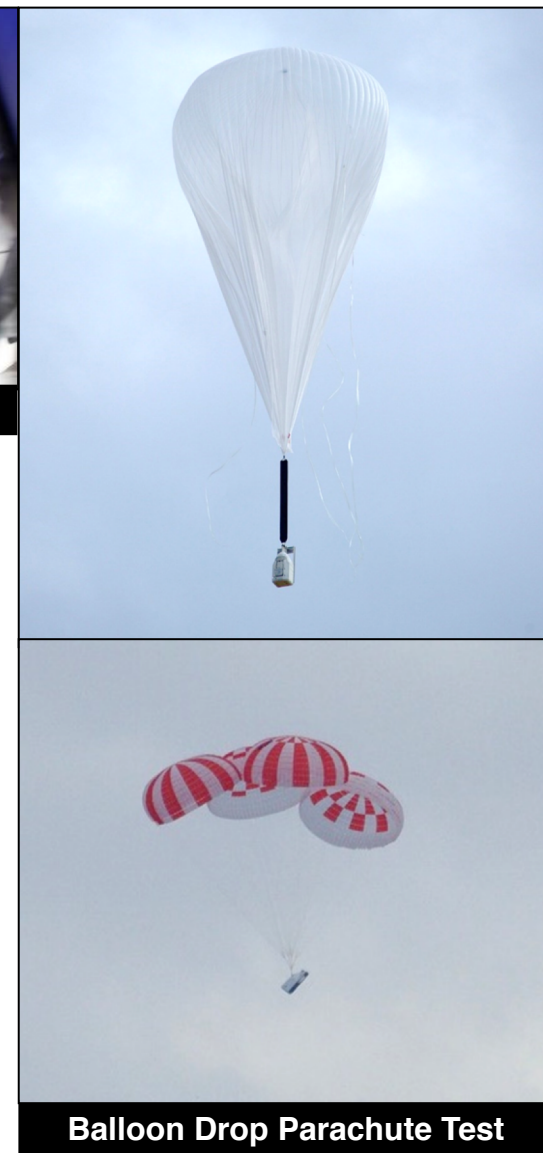
- Dragon stacked testing completed
 - RF/EMI
 - TVac
 - Modal & Acoustic
- Validation Prop Module
 - Low flow testing complete
 - High flow testing in work
- Suit quals ongoing
- Crew Display Evaluation 5 completed
- Completed Training Events 1, 2 and 3: suited simulations with the cadre in buck, functioning displays, flight software, audio comm systems; launch and ascent, and approach through docking
- Software Stage Test with ISS complete
- Parachutes: balloon drop test complete, 45k feet

- **Falcon 9 (Block 5)**

- M1D qual turbine wheel tests in work
- COPV 2.0
 - Qualification complete, safe-life demonstration ongoing
 - 50 LOX cycles, 200 LN2 cycles, 10 flight cycle life testing complete
 - Demo-1 flight bottles installed

- **In-Flight Abort Test**

- Test plan, test configuration, instrumentation, conops and loads analysis delivered
- Trunk manufacture in work





SpaceX Accomplishments



- **Demo-1 vehicle progress (SN 2-1)**

- **Dragon**

- Capsule delivered to Cape and in final processing
- VRIO R&R completed, testing post R&R upcoming
- Trunk at Hawthorne for solar array install

- **Falcon**

- F9 1st stage on track for fall shipping
- In Lane 4 integration
- Center Pusher installed
- Interstage mated to tank
- Octaweb fully populated with hot-fired Merlins

- **Ops**

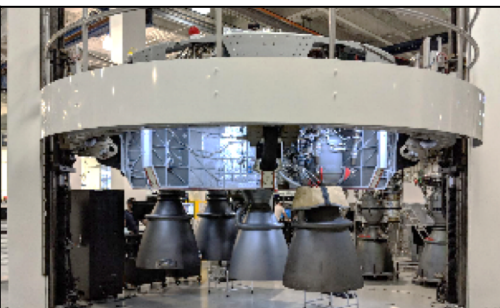
- Completed final Flight Operational Readiness reviews
- Three joint ops sims completed
- First Mission Management Team training sim completed



Demo-1 Dragon Arrival at the Cape



Demo-1 Falcon



Demo-1 Octaweb



Demo-1 Acoustic Test



SpaceX Demo-1 Accomplishments



- Crew Training Event 3 completed August
- Completed Launch & Ascent, and Approach through Docking Sims with suited cadre, functioning displays, flight software, & audio comm systems; Software Stage Test with ISS complete
- Parachutes: balloon drop test complete, 45k ft
- Capsule delivered to Cape, in final processing
- VRIO R&R completed, testing post R&R upcoming
- Trunk at Hawthorne for solar array install
- Completed final Flight Operational Readiness reviews
- Three joint ops sims completed
- First & second Mission Management Team training sim complete, third planned





SpaceX Demo-2 Accomplishments



- **Demo-2 vehicle progress (SN 2-3)**

- Integration mate complete
- Ongoing integration in cleanroom
- Trunk primary structure complete
- Cabin build out started

- **LC-39A**

- Successful dry run of Day of Launch Closeout Crew procedures with representative crew members, space suits, and Model X's.
- Successful Crew Arm Seal Testing; demonstrated that the seal can keep out the environment (performed a water test) and will adhere to Dragon when the vehicle translates
- Crew Access Arm installation complete
- On track for final Launch Site Operational Readiness Review in September



Demo-2 vehicle



Demo-2 Display Testing



Demo-2 Vehicle Status



Crew Training for Demo-2

Demo-2 Dragon

- Pressure Section to Service Section integration mate complete
- Ongoing vehicle integration in cleanroom
- Trunk primary structure complete
- Cabin build out started

Crew Ops & LC-39A

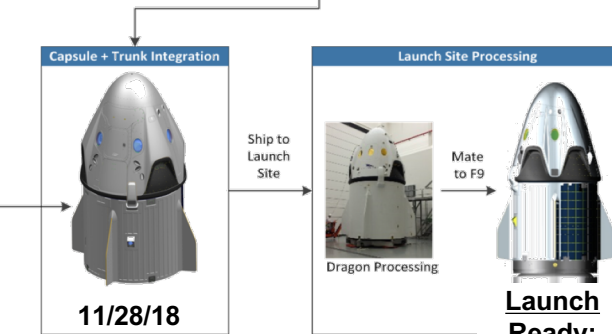
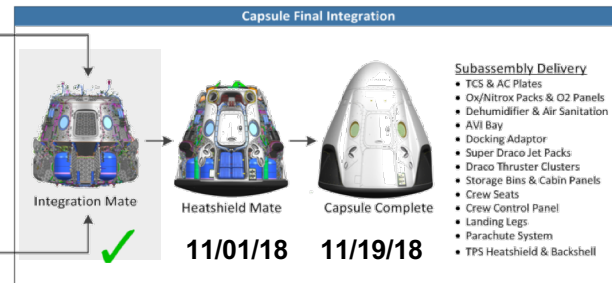
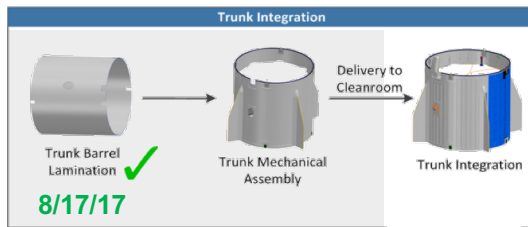
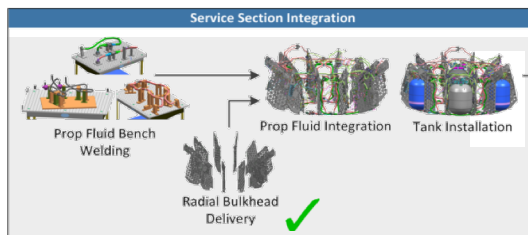
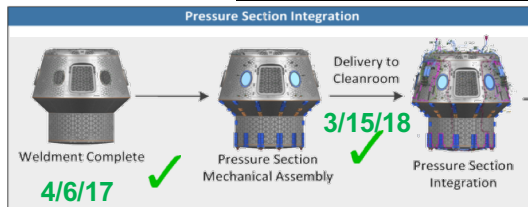
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Demo-2 Trunk



Demo-2 Capsule Integration



Launch Ready: January



Space Act Agreements





Blue Origin Status



Commercial Space Capabilities Collaboration (CSCC) Space Act Agreement (SAA)

- **Technical Exchanges**

- Structures and Dynamics
- Design Reviews
- Launch Vehicle Materials
- Historical STS data and reports

- **Data Exchange**

- Various software requests and technical documentation exchanges in work

- **Look Ahead**

- Milestone #6, Development Update of Ground and Mission Operations, Nov. 2018
- Continued Technical and Data Exchange





Commercial Crew Integrated Capabilities (CCiCap) Space Act Agreement (SAA)

- **CCiCap SAA Milestone 4b, Engineering Test Article Flight Testing #2 NASA outbrief - December 2017**

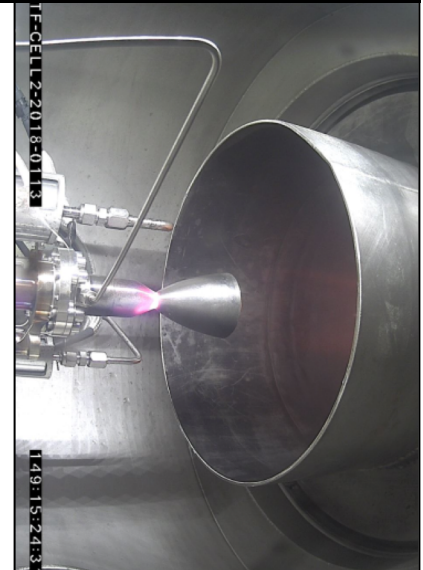
- Successful uncrewed Dream Chaser engineering test article (ETA) approach & landing test (ALT-2) at Armstrong Flight Research Center - Edwards Air Force Base
- SNC Post-flight data analysis is complete
 - All mission objectives achieved
 - ALT-2 in-flight performance nominal for orbital vehicle Avionics & FSW, FADS, and GN&C
 - Landing rollout performance validated by multiple range and taxi tests
 - Final ALT-2 Test Report sent to both NASA CCP and NASA CRS2 programs

- **Dream Chaser Design and Development Activities**

- Dream Chaser systems level design at near-CDR maturity
- Reaction Control System (RCS) has 20 thrusters and each can produce three thrust levels (Low=10psf monoprop, Med=55psf monoprop, High=110psf bi-prop)
 - Thruster performance exceeds expectations to date
- Dream Chaser Aero Database update in progress includes ETA flight + Cubrc & AEDC WTT testing. ECD 4th Qtr 2018
- Dream Chaser Tail #1 cabin/body assembly delivery expected Feb 2019
- Multiple cargo demonstrations (using UDC) occur in Aug/Sep 2018



Dream Chaser ALT-2



DC Pathfinder 1 High Thrust 1.5 sec



Enabling Commercial Space



- **CCP helps to facilitate Inter-Agency, Intergovernmental and International partnerships, agreements, and legislation with the strategic goal of enabling the commercial space industry**
 - Inter-Agency Collaboration
 - Federal Aviation Administration (FAA)
 - Department of Defense (DoD)
 - Department of Commerce (DOC)
 - Federal Communications Commission (FCC)
 - National Telecommunications and Information Administration (NTIA)
 - National Transportation and Safety Board (NTSB)
 - Legislation and Regulation
 - “Government Astronaut” classification
 - Mission licensing to include launch, re-entry, launch site and operator
 - Public health and safety protections
 - Jurisdiction and authority during different phases of flight
 - Independent investigation authority
 - Spectrum Usage
 - Ensure secure communication pathway availability
 - Liability and Insurance
 - Cross waivers
 - Financial responsibility
 - Third-party indemnification
 - Government property



Summary



- **CCP continues to facilitate the development and certification of U.S. industry-based Crew Transportation Systems**
- **Boeing and SpaceX are meeting contractual milestones and maturing their designs**
 - A significant amount of hardware is in development, test, and qualification in preparation for upcoming missions
 - Risks are being identified and important design challenges are being addressed
 - NASA is engaged in meaningful insight
- **Both providers are making tangible progress toward flight tests and crewed missions to the International Space Station**
- **CCP has robust and efficient processes for certification, including addressing waivers and deviations**
 - Progress is being made in the burn down of key certification products with the providers
- **Crew members have been assigned to missions**
- **Inter-agency work continues to enable the commercial spaceflight industry**
- **In preparation for flight, there is significant work ahead**



Boeing CST-100 Starliner



SpaceX Crew Dragon

